HANDBOOK

ON

FOREST MENSURATION

OF

THE WHITE PINE

IN

MASSACHUSETTS, State forester

HOW TO ESTIMATE STANDING TIMBER; LOG SCALES; VOLUME TABLES; YIELD TABLES; FINANCIAL ROTATIONS; GROWTH TABLES; THINNINGS, ETC.

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TABLE OF CONTENTS.

REASONS FOR PUBLISHING.

This handbook is published by the State Forester that our people in Massachusetts may have at their disposal information as to how they may determine, by simple measurements and the use of tables, the yields, and hence the values, of pine trees, from the commercial or lumberman's standpoint.

The time has come when we should have a better practical working knowledge of forest values. Forest products continue to become more valuable yearly. It is believed that business men and all persons at all interested in forestry matters, as well as lumbermen and farmers, can get much that is of value from the tables and general information contained in this handbook. There is no reason why a person owning white pine growth, whether a small or a large tract, should not be able to determine practically how much lumber it is capable of producing, and hence its value, even before the trees are cut, if he cares to do so. This handbook will assist him in doing this very thing.

Trees are easy of access, and can be estimated with great accuracy. The old idea, that a man must spend a lifetime as an estimator or cruiser in order to determine accurate yields from tree growth, is rapidly passing. The time of guesswork is being replaced by more definite knowledge.

In order to secure the data contained in the tables, the State Forester has had measurements of white pine taken in all parts of Massachusetts by trained men, and the data have been submitted to practical experts as well, so we feel the work is authoritative.

ACKNOWLEDGMENTS.

The work of compiling and tabulating this information was placed in the hands of Mr. H. O. Cook, M.F., a graduate of the Harvard Forestry School, and specially recommended by Prof. Austin Cary of Harvard for the work. Several Harvard and Yale forestry students were employed during the summer vacation of 1907 on this work.

The measurements and tabulations for the log scales and volume tables were made in 1905, under the direction of Ralph C. Hawley, former assistant in this office, and at present instructor in the Yale Forestry School. Some of these tables were published in the third annual report of the State Forester, 1906, but as that document had a very limited distribution, they are repeated here for more general use.

Prof. Austin Cary, Department of Forestry, Harvard University, has kindly examined much of the work, and made valuable suggestions.

The excellent chapter on white pine measurements in the report of the New Hampshire Forestry Commission for 1906 has also been very valuable as a guide, and as a means of checking the tables in this treatise.

F. W. RANE,
State Forester.

STATE HOUSE, BOSTON, MASS., Sept. 1, 1908.

LOG SCALES.

A log scale is a table showing the number of board feet that, in general, can be sawed from a log of given dimensions, these dimensions being the length, the diameter inside the bark at the small end or the diameter outside the bark at the middle of the log.

The following scales were made from mill tallies. Over twelve hundred logs at twelve mills were carefully measured, followed through the saw and the number of board feet that each log cut in lumber, round and square edge, noted. Most of the mills sawed inch boards, but one sawed largely inch and a quarter, while another got out largely two and one-eighth inch planks. It is impossible to indicate the percentage of square-edge as compared with round-edge, on account of the wide variations between the different mills, but it runs from nothing in the smallest logs to more than 50 per cent. in the largest. The mills were all of the steam portable variety except one, which was run by water power.

The scales are commended for use in all transactions involving the buying and selling of logs, because they are based on conditions of sawing found in this State, and are the results of averaging the saw-bill of a large number of logs at many mills. They have since been tested on nearly two hundred logs at three mills, and found to be entirely dependable, except in the case of the largest logs, for which the data were insufficient, and then they are inclined to underrun.

There are no restrictions on the use of these rules, and any one can with a little ingenuity construct a flat scale or even a pair of calipers from which the number of board feet can be read off as the logs are measured.

Log Scale for White Pine, — 1-Inch Boards.

Based on the measurement of 1,209 logs sawed in Massachusetts mills. Circular saw, ¼-inch kerf.

Diameter, Inside Bark at Small End (Inches).	Length of Log (Feet).			
	10	12	14	16
	Ft. B. M.	Ft. B. M.	Ft. B. M.	Ft. B. M.
4, ...	9	13	17	21
5, ...	13	17	21	26
6, ...	17	22	27	32
7, ...	23	29	35	40
8, ...	30	37	44	51
9, ...	39	47	55	64
10, ...	48	58	68	79
11, ...	58	70	82	98
12, ...	69	83	97	115
13, ...	80	96	113	136
14, ...	92	111	131	158
15, ...	104	129	150	180
16, ...	117	146	170	205
17, ...	131	165	192	230
18, ...	-	184	220	256
19, ...	-	206	243	288
20, ...	-	230	272	-
21, ...	-	255	300	-
22, ...	-	280	330	-
23, ...	-	310	-	-
24, ...	-	340	-	-

Log Scale for White Pine, — 1-Inch Boards.

Based on measurements of 1,209 logs sawed in Massachusetts mills. — Circular saw, ¼-inch kerf.

Diameter, Outside Bark at Middle of Log (Inches).	Length of Log (Feet).			
	10	12	14	16
	Ft. B. M.	Ft. B. M.	Ft. B. M.	Ft. B. M.
5, ...	8	12	16	20
6, ...	12	16	20	24
7, ...	15	20	25	30
8, ...	20	26	31	36
9, ...	26	33	39	45
10, ...	34	41	49	57
11, ...	42	51	60	70
12, ...	51	62	75	86
13, ...	61	73	88	105
14, ...	71	85	103	120
15, ...	82	99	120	140
16, ...	93	116	137	162
17, ...	104	132	156	184
18, ...	116	148	175	206
19, ...	130	166	195	230
20, ...	-	185	218	257
21, ...	-	204	240	285
22, ...	-	226	266	312
23, ...	-	250	292	-
24, ...	-	275	322	-
25, ...	-	296	350	-

VOLUME TABLES.

The volume tables of white pine give the amount in any stated unit, of wood that one may expect to obtain from the merchantable portion of a tree of the given dimensions.

A PINE STAND AT PLYMOUTH MARKED FOR THINNING.

The merchantable portion of the tree, in this instance, is considered to be that part of the trunk above a one-half-foot stump and below a four-inch top.

In making the board-foot table, where practicable the trees were measured as they were chopped, and the individual logs identified by numbers. These logs were then followed through the mill, and thus the number of board feet which the tree yielded was obtained. In the other cases, a log rule was constructed at each mill, after the manner described

THE SAME STAND AFTER THINNING.

for the general log rule, and the logs into which each tree was divided were scaled by this rule.

It is not pretended that these tables will give the exact volume of any tree fulfilling the required dimensions, but they are for use only where a large number of trees are concerned, of which they will present a good average, based as they are on measurements made on more than thirteen hundred trees.

The utility of these tables lies in the estimating of standing timber. It allows the wood-lot owner an opportunity to obtain an estimate of the amount of pine on his lot, and

puts him more nearly on an equality with the lumber buyer, with whom estimating is a matter of the practised eye.

A dozen different methods of estimating might be suggested in which volume tables play a part and which vary greatly in accuracy.

The most accurate and the best method for small lots is to caliper every tree on it, thus obtaining their number and their diameters. Then obtain the average height of the stand, if it is the even height that most pine stands are; otherwise, it will be necessary to divide the trees into two or more classes, according to their diameters, and to get the average height of each class. From the tables obtain the volume of each tree, all of which, added together, form the volume of the stand.

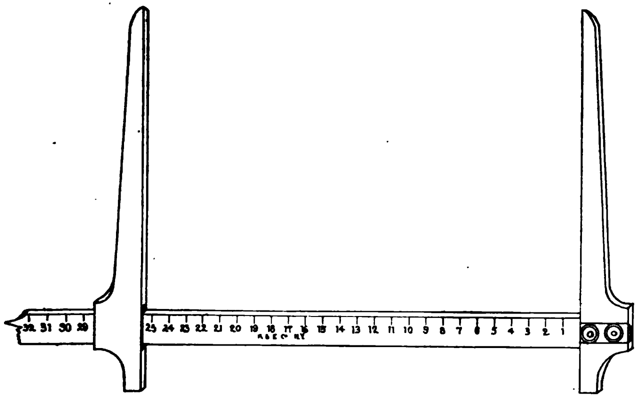
A second method is to select a "sample plot" of known area, preferably one-quarter acre, in what appears to be an average portion of the stand. A circle with a 59-foot radius or a square 104 feet on a side encloses one-quarter acre. Caliper all the trees on this plot, measure the average height, and obtain the volume as before. The total volume will be to this volume as the total area is to the area of the sample plot.

A simple but yet a more uncertain method is to count all the trees on the lot or on a sample area, and then to select a tree that appears to be of the average size, scale it by the table, and multiply its volume by the total number of trees.

The simplest way of getting at the height of the stand is to cut down an average tree and measure it with a tape. Fallen trees can often be found on the ground. Any instrument that reads angles, a measuring tape, and the application of a little trigonometry will give the desired results. Foresters use an instrument called a Faustmann's hyp

someter, manufactured by the Keuffel & Esser Company of Hoboken, N. J., and which costs \$6.50. Great accuracy in this work is not necessary, as the tables read only to 10-foot classes. (See extract from "Woodsman's Handbook," on page 47.)

A caliper of great convenience for use in connection with these volume tables and log scales consists of a beam 36



TREE CALIPER

inches long and graduated into inches and tenths. At the left end is a rigid arm set at right angles to the beam, while another arm is so fixed that it will slide back and forth at will. These calipers can be purchased from the Keuffel & Esser Company for \$4.50. With a yard stick and a few tools one could construct for himself a pair of calipers along similar lines and of sufficient utility.

To obtain the volume table in cords, each log was calipered by the caliper rule, and the volume of the tree expressed in

decimal parts of a cord. This rule is, briefly, computed b squaring the average diameter of the log in inches, multiply ing by the length in feet and dividing the result by 144. Th result is the volume of the log in cylindrical feet, and th has been translated into decimal parts of a cord in t Humphrey rule.

The last two tables give the volume of the merchantabl part of the bole in cubic feet of solid wood, one with an one without bark. These tables are of scientific rather tha of practical value. In Germany and in Europe, generally timber (logs and trees) is sold by the solid cubic content expressed in feet and metres. This unit has certain adva tages, because all the factors of waste that enter into calc lations of board feet, such as crooks, thickness of slab, saw kerf, etc., are eliminated; but so long as we continue to buy and sell trees on the commercial units of board feet and cords, tables of cubic contents will be of theoretic interes only.

Volume Table, in Board Feet, for White Pine in Massachusetts.

Scaled by rule made from mill tallies. Volume to 4-inch top. Stumps taken at ½ foot.

Diameter, Breast-high (Inches).	Total Height (Feet).						
	30	40	50	60	70	80	90
	Bd. Ft.	Bd. Ft.	Bd. Ft.	Bd. Ft.	Bd. Ft.	Bd. Ft.	Bd. Ft.
5, ...	10	-	-	-	-	-	-
6, ...	15	20	30	-	-	-	-
7, ...	20	30	40	50	65	-	-
8, ...	25	35	50	65	85	-	-
9, ...	30	45	60	80	105	115	-
10, ...	-	55	75	95	125	145	-
11, ...	-	65	90	115	145	170	200
12, ...	-	75	105	135	165	200	230
13, ...	-	90	120	155	190	235	260
14, ...	-	-	135	175	215	265	300
15, ...	-	-	155	195	245	300	340
16, ...	-	-	175	215	270	335	380
17, ...	-	-	-	240	300	370	420
18, ...	-	-	-	260	325	405	465
19, ...	-	-	-	280	355	445	510
20, ...	-	-	-	305	385	485	555
21, ...	-	-	-	-	420	525	605
22, ...	-	-	-	-	450	570	650
23, ...	-	-	-	-	480	620	700
24, ...	-	-	-	-	515	665	750
25, ...	-	-	-	-	550	715	800
26, ...	-	-	-	-	-	-	855
27, ...	-	-	-	-	-	-	905

Volume Table, in Cords, for White Pine in Massachusetts.

Volume to 4-inch top. Stumps taken at ½ foot. Logs scaled by caliper rule.

Diameter, Breast-high (Inches).	Total Height (Feet).						
	30	40	50	60	70	80	90
	Cords.	Cords.	Cords.	Cords.	Cords.	Cords.	Cords.
5,	.03	-	-	-	-	-	-
6,	.03	.04	.05	-	-	-	-
7,	.04	.05	.07	.09	-	-	-
8,	.05	.07	.09	.11	.13	-	-
9,	.07	.09	.11	.13	.16	-	-
10,	-	.11	.13	.16	.19	.22	-
11,	-	.13	.16	.19	.23	.26	.30
12,	-	.15	.19	.22	.27	.31	.35
13,	-	.17	.22	.26	.31	.36	.40
14,	-	-	.25	.30	.34	.41	.45
15,	-	-	.28	.34	.40	.46	.51
16,	-	-	.32	.38	.44	.52	.58
17,	-	-	-	.42	.49	.58	.64
18,	-	-	-	.47	.55	.64	.71
19,	-	-	-	.51	.60	.70	.79
20,	-	-	-	.55	.66	.77	.87
21,	-	-	-	-	.72	.85	.95
22,	-	-	-	-	.78	.92	1.04
23,	-	-	-	-	.84	1.01	1.13
24,	-	-	-	-	.90	1.08	1.22
25,	-	-	-	-	.97	1.16	1.32
26,	-	-	-	-	-	-	1.42
27,	-	-	-	-	-	-	1.51

Volume Table, in Cubic Feet, for White Pine in Massachusetts.

Volume *outside* bark, up to a 4-inch top. Stumps taken at ½ foot.

Diameter, Breast-high (Inches).	Total Height (Feet).						
	30	40	50	60	70	80	90
	Cu. Ft.	Cu. Ft.	Cu. Ft.	Cu. Ft.	Cu. Ft.	Cu. Ft.	Cu. Ft.
5,	1.8	-	-	-	-	-	-
6,	2.6	3.3	4.3	-	-	-	-
7,	3.4	4.4	6.1	7.7	-	-	-
8,	4.5	6.0	7.8	9.8	12.0	-	-
9,	5.9	7.7	10.0	12.0	15.0	-	-
10,	-	9.6	12.0	15.0	17.9	20.9	-
11,	-	11.6	14.6	17.9	21.4	24.9	28.7
12,	-	13.9	17.6	21.1	25.3	29.8	33.7
13,	-	16.2	20.4	24.8	29.2	34.7	38.7
14,	-	-	23.7	28.7	32.5	39.6	43.6
15,	-	-	26.8	32.6	37.9	44.5	49.5
16,	-	-	30.5	36.5	42.3	49.8	55.9
17,	-	-	-	40.3	47.2	56.7	62.3
18,	-	-	-	44.6	52.6	61.5	69.1
19,	-	-	-	49.0	57.9	67.8	76.9
20,	-	-	-	52.9	63.2	74.7	84.8
21,	-	-	-	-	69.1	82.0	92.6
22,	-	-	-	-	74.9	89.3	101.4
23,	-	-	-	-	81.3	98.1	110.8
24,	-	-	-	-	87.1	104.9	119.0
25,	-	-	-	-	94.0	112.6	128.8

Volume Table, in Cubic Feet, for White Pine in Massachusetts.

Volume *inside* bark up to a 4-inch top. Stumps taken at ½-foot.

Diameter, Breast-high (Inches).	Total Height (Feet).						
	30	40	50	60	70	80	90
	Cu. Ft.	Cu. Ft.	Cu. Ft.	Cu. Ft.	Cu. Ft.	Cu. Ft.	Cu. Ft.
5, ...	1.5	–	–	–	–	–	–
6, ...	2.3	3.0	3.7	–	–	–	–
7, ...	3.3	4.1	5.2	6.3	8.0	–	–
8, ...	4.2	5.5	6.8	8.5	10.8	–	[illegible]
9, ...	5.1	7.0	8.7	10.7	13.5	15.0	[illegible]
10, ...	–	8.7	10.6	13.4	16.3	18.5	[illegible]
11, ...	–	10.4	12.9	16.0	19.3	22.5	[illegible]
12, ...	–	12.3	15.3	19.0	22.7	26.5	[illegible]
13, ...	–	14.0	18.0	22.0	26.5	31.0	[illegible]
14, ...	–	–	20.8	25.5	30.0	35.5	[illegible]
15, ...	–	–	24.0	28.7	34.0	40.5	44.5
16, ...	–	–	27.3	32.3	38.5	45.5	50.5
17, ...	–	–	–	36.0	43.0	51.0	56.5
18, ...	–	–	–	39.5	47.5	56.5	63.0
19, ...	–	–	–	43.2	52.5	62.0	69.5
20, ...	–	–	–	47.0	57.5	68.0	75.5
21, ...	–	–	–	–	62.5	74.5	82.5
22, ...	–	–	–	–	67.5	81.0	90.0
23, ...	–	–	–	–	73.0	88.0	97.0
24, ...	–	–	–	–	78.5	95.0	104.5
25, ...	–	–	–	–	84.0	102.0	112.0

YIELD TABLES.

A yield table is intended to show the number of board feet or other unit that one may hope to obtain from an acre of white pine at different ages. As the amount of pine per acre in stands of the same age varies widely under different conditions of growth, certain things must be presupposed:

A PURE, EVEN-AGED WHITE PINE STAND.

irst, that the stand is pure, that is, containing no other trees ›ut pine; second, that it is even-aged, or approximately so; ınd third, that it is fully stocked, that is, without proıounced holes or blanks. Planted stands would best fit this lescription, and this table is intended primarily for those vho contemplate planting, because through them one can ell very nearly what yield to expect from his stand at any iven time. It is to be supposed that a planted stand will row at least as well as a natural stand under the same cir-

more often better, so that for planted pine these
hough taken from the best of natural stands,
onservative. As the planting of white pine be-
. year more necessary, more common and more
we invite a careful inspection of the following

aterial for this table, a large number of sample
were made in stands fulfilling the requirements
y of ages and in all parts of the State. The
s of one-quarter or one-eighth acres were laid out
ll the trees thereon calipered, and the average
n. From the volume tables the total volume was
ed. These sample plots were then transferred to
n paper, on which the ordinates represented age
scissæ volume in board feet. These points were
d into three belts, — the fast-growing, the slow-
d the belt of average growth, known as qualities
I, respectively. Curves were then drawn through
of each belt, and the figures of the table read
curves. This same process was gone through
e three units of board feet, cords and cubic feet.
oney yield table, volume in board feet is trans-
lars and cents through the substitution of certain
thousand feet B.M., which were determined upon
ltation with practical lumbermen. In the second
ich gives the f. o. b. value of the lumber sawed
s of different ages, $16, a price below the average
ut on the young stands from which only small
r lumber could be cut, while $20 per M feet, a
r than the average, is given to the oldest stands,
d cut a considerable quantity of clear plank or
grade lumber. On account of the slower rate of

growth in the second and third qualities, the range of value has been shifted somewhat, and in the third the $20 grade has been eliminated altogether. The stumpage values range from $6 to $12 per M, and are distributed under the same plan as the f. o. b. values. Although the f. o. b. values are fairly uniform throughout the State, the stumpage rates vary widely, and are dependent chiefly on the distance from the stand to the railroad. Stands two to four miles from the railroad are supposed in this case.

Yield Table for White Pine.

Age (Years).	Quality I.			Quality II.			Quality III.		
	1-Inch Boards.	Cords.	Cubic Feet.	1-Inch Boards.	Cords.	Cubic Feet.	1-Inch Boards.	Cords.	Cubic Feet.
25, ...	10,825	25.1	2,080	6,750	16.4	1,300	3,975	10.8	750
30, ...	19,900	44.0	3,750	12,500	31.2	2,740	7,500	18.2	1,400
35, ...	31,150	60.4	5,420	24,400	49.0	4,375	16,950	35.8	3,035
40, ...	40,650	70.6	6,590	32,800	58.0	5,300	25,200	46.2	4,080
45, ...	49,350	78.0	7,420	40,600	64.8	6,075	32,100	51.8	4,785
50, ...	55,150	84.2	8,035	46,500	70.0	6,725	37,550	56.6	5,475
55, ...	59,650	89.2	8,575	50,550	74.8	7,200	42,100	60.8	6,015
60, ...	63,600	93.4	9,075	53,200	79.2	7,655	44,550	64.6	6,340
65, ...	67,050	97.2	9,550	56,600	83.0	8,050	46,150	68.4	6,550

Money Yield Table.

Manufactured and stumpage values.

Age (Years).	Quality I.					Quality II.					Quality III.				
	Volume.	Per M. Ft.	F. O. B. Value.	Per M. Ft.	Stumpage.	Volume.	Per M. Ft.	F. O. B. Value.	Per M. Ft.	Stumpage.	Volume.	Per M. Ft.	F. O. B. Value.	Per M. Ft.	Stumpage.
	Bd.Ft.					Bd.Ft.					Bd.Ft.				
25, . . .	10,825		$173 20	$6 00	$65 00	6,750		$108 00	$6 00	$40 50	3,975		$63 60		$23 85
30, . . .	19,900	$16 00	318 40		119 40	12,500	$16 00	200 00		75 00	7,500	$16 00	120 00	$6 00	45 00
35, . . .	31,150		498 40		249 20	24,400		439 20		195 20	16,950		271 20		101 70
40, . . .	40,650		791 70	$8 00	325 20	32,800		590 40	$8 00	262 40	25,200		408 20		201 60
45, . . .	49,350	$18 00	888 30		394 80	40,600		730 80		324 80	32,100		577 80	$8 00	256 80
50, . . .	55,150		992 70	$10 00	551 50	46,500	$18 00	837 00		465 00	37,550		676 00		300 40
55, . . .	59,650		1,193 00		596 50	50,550		910 00	$10 00	505 50	42,100	$18 00	757 80		336 80
60, . . .	63,600	$20 00	1,272 00	$12 00	763 20	53,200	$20 00	1,064 00		532 00	44,550		802 00	$10 00	445 50
65, . . .	67,050		1,341 00		804 50	56,600		1,132 00		566 00	46,150		830 70		461 50

FINANCIAL ROTATION.

Yield tables are useful mainly that one may determine through them at what age the crop will yield the highest net returns, — the age called by foresters the "financial rotation." Timber crops are peculiar in that, although they yield a high annual return, this return cannot be realized until after a period of years, so that it is not alone necessary to deduct the actual expenses from the gross returns in order to obtain the net yield, but that these expenses be reckoned from the date of their incurrence with compound interest at some determined rate. The rate of interest should be that which an investment of equal security will yield. As many savings banks now pay 4 per cent., we cannot use a rate less than that, and it should be higher, — how much depends on the risk from fire and other dangers. We offer three tables, with interest reckoned at 4, 5 and 6 per cent.

The gross returns are the stumpage value, quality II, from the money yield table, supposing this to be the return from the average of planted stands throughout the State.

The expenses are first of all the taxes on the timber and land, reckoned at two cents on a dollar on a two-thirds valuation. The timber is supposed not to have been taxed until it is twenty-five years old, and that it is valued every five years thereafter. The value of the land at $4 an acre is a fair valuation of cut-over and waste land fit for planting, which can be found in many parts of the State. The cost of planting, $7, is based on the cost of seedlings at $4 a thousand and $3 for labor. One expense, that is figured into all business, must here be omitted, and that is, insurance, because there are no companies insuring standing timber. A little labor put into the construction of fire lines

and the clearing of brush will provide protection from fire at a cost of less than 10 cents a year for each acre of land.

The expenses compounded at 4 per cent. and subtracted from the gross returns leave the highest net income ($307.15) with a fifty-year rotation. At 5 per cent. the rotation is fifty years and the net profits are $248. At 6 per cent. the net profit is reduced to $158. Higher rates of per cent. would still further reduce the net income, and would also shorten the rotation. In this connection one must note this fact, that the net profits are over and above the regular interest returns on the money invested, and also note, in considering these profits, that the stumpage price of pine, here the gross returns, is constantly advancing, while the average rate of interest on safe investments is constantly falling. These two factors would tend to greatly increase the net profits as time goes on.

The last table, on financial rotation, is in the form of a summary and a means of comparison, because a range of values is given to the land and to the cost of planting. By decreasing the value of the land, by doing the planting more cheaply, or by using a smaller rate of interest, the net profits are increased and the rotation lengthened. Conversely, by increasing any or all of these items the net income and the rotation are reduced. This change in rotation is not apparent from the tables, but would be if the rotation were given for every year, instead of for five-year periods.

Financial Rotation of White Pine.

Money at 4 per cent.; value of land, $4 per acre; cost of planting, $7 per acre.

ROTATION (YEARS).	Gross Returns Stumpage Value.	EXPENSES.						Net Profits.
		TAXES.			COST OF PRODUCING.		Total Expenses.	
		TAXES ON TIMBER.		Taxes on Land accrued to End of Rotation.	Interest on Value of Land accrued.	Cost of Planting carried to End of Rotation.		
		Annual for Five-year Periods.	Accrued to End of Rotation.					
25, . . .	$40 50	$0 54.0	-	$2 17	$6 66	$18 66	$27 50	$13 00
30, . . .	75 00	1 00.0	$3 03	2 90	8 97	22 70	37 60	38 40
35, . . .	195 20	1 26.9	9 32	3 82	11 78	27 62	52 54	142 66
40, . . .	262 40	3 49.8	18 47	4 92	15 20	33 61	72 20	190 20
45, . . .	324 80	4 33.0	42 16	6 25	19 36	40 89	108 66	216 20
50, . . .	465 00	6 20.0	75 76	7 90	24 43	49 75	157 85	307 15
55, . . .	505 50	6 74.0	127 04	9 90	30 58	60 52	228 05	277 45
60, . . .	532 00	7 08.0	192 60	11 35	38 08	73 64	315 68	216 32
65, . . .	566 00	7 54.8	281 32	15 18	47 20	89 60	433 28	132 72

Financial Rotation of White Pine — Continued.

Money at 5 per cent.; value of land, $4 per acre; cost of planting, $7 per acre.

Rotation (Years).	Gross Returns Stumpage Value.	Expenses.						Net Profits.
		Taxes.			Cost of Producing.		Total Expenses.	
		Taxes on Timber.		Taxes on Land accrued to End of Rotation.	Interest on Value of Land accrued.	Cost of Planting carried to End of Rotation.		
		Annual for Five-year Periods.	Accrued to End of Rotation.					
25, . . .	$40 50	$0 54.0	–	$2 50	$9 54	$23 70	$35 75	$4 75
30, . . .	75 00	1 00.0	$3 13	3 48	13 30	30 25	50 15	24 85
35, . . .	195 20	1 26.9	9 80	4 73	18 06	38 61	71 20	124 00
40, . . .	262 40	3 49.8	19 85	6 54	24 16	49 28	99 83	162 57
45, . . .	324 80	4 33.0	45 60	8 37	31 94	62 90	148 82	175 98
50, . . .	465 00	6 20.0	83 36	10 99	41 87	80 27	216 50	**248 50**
55, . . .	505 50	6 74.0	142 37	14 30	54 54	102 45	313 66	191 84
60, . . .	532 00	7 08.0	220 82	18 55	71 70	130 75	441 83	90 17
65, . . .	566 00	7 54.8	331 40	23 97	91 35	166 88	613 60	—47 50 [1]

Money at 6 per cent.; value of land, $4 per acre; cost of planting, $7 per acre.

25, . . .	$40 50	$0 54.0	-	$2 90	$17 17	$30 04	$50 10	—$9 61 [1]
30, . . .	75 00	1 00.0	$3 21	4 18	22 97	40 20	70 56	—4 44 [1]
35, . . .	195 20	1 26.9	10 28	5 90	30 72	53 80	100 69	94 51
40, . . .	262 40	3 49.8	21 30	8 20	45 14	72 00	146 64	115 76
45, . . .	324 80	4 33.0	49 48	11 26	55 06	96 35	212 15	112 65
50, . . .	465 00	6 20.0	89 04	15 37	73 68	128 94	307 03	151 97
55, . . .	505 50	6 74.0	160 30	20 87	98 60	172 55	452 32	53 18
60, . . .	532 00	7 08.0	255 23	28 23	131 94	230 90	646 30	—114 30 [1]
65, . . .	566 00	7 54.8	390 52	38 08	176 56	308 98	914 14	—348 14 [1]

[1] Minus sign means a loss; the investment bringing less than 6 per cent. interest return.

Financial Rotation of White Pine — Concluded.

Changes in Net Profits with Variation in Cost of Land and Planting.

Money valued at —	Value of Land, $2 per Acre.					
	Planting, $5.		Planting, $7.		Planting, $10.	
	Financial Rotation.	Net Profit.	Financial Rotation.	Net Profit.	Financial Rotation.	Net Profit.
	Years.		Years.		Years.	
4 per cent., .	50	$331 60	50	$323 35	50	$302 50
5 per cent., .	50	298 56	50	275 43	50	241 00
6 per cent., .	50	239 35	50	202 50	50	147 25

Money valued at —	Value of Land, $4 per Acre.					
	Planting, $5.		Planting, $7.		Planting, $10.	
	Financial Rotation.	Net Profit.	Financial Rotation.	Net Profit.	Financial Rotation.	Net Profit.
	Years.		Years.		Years.	
4 per cent., .	50	$321 37	50	$307 15	50	$285 84
5 per cent., .	50	271 43	50	248 50	50	214 10
6 per cent., .	50	194 80	50	158 00	50	102 70

Money valued at —	Value of Land, $6 per Acre.					
	Planting, $5.		Planting, $7.		Planting, $10.	
	Financial Rotation.	Net Profit.	Financial Rotation.	Net Profit.	Financial Rotation.	Net Profit.
	Years.		Years.		Years.	
4 per cent., .	50	$305 17	50	$290 96	50	$269 64
5 per cent., .	50	245 00	50	222 10	50	187 68
6 per cent., .	50	150 30	50	113 46	50	58 20

THINNINGS.

Pine trees in growing demand a certain amount of space and light for their best development, and this demand increases as the tree grows in size. In the course of time the more thrifty outstrip their weaker neighbors and overtop them, shutting them off from the light of the sun until they rapidly sicken and die. In this contest the growth of the dominant trees is retarded, and that of the suppressed trees becomes practically *nil*. It is to prevent this struggle that foresters advocate the making of thinnings, that is, the taking out of the suppressed and nearly suppressed trees, together with all crooked and diseased specimens, whether suppressed or not.

In measuring the sample plots for the yield tables special note was made of the trees that, in the judgment of the men, would come out if thinnings were to be made. The volume of trees over five inches in diameter, breast high, was ascertained from the volume tables, and a table constructed in the same manner as the yield table. For the lumber and for the stumpage values low prices have been set, as the material is slightly more expensive to get out, and of an inferior quality to the trees that would be obtained in cutting clean a stand of the same age.

For trees under five inches no record was kept, as the volume tables do not give the contents of trees of less size than that. Such small growth must, however, enter largely into the volume of thinnings, and in the younger stands form the greater part. I have taken from the report of the New Hampshire Forestry Commission that portion of their thinning table which gives the cubic feet contents of trees under five inches D.B.H., and translated it into cords at the

ratio of one hundred cubic feet to a cord, that being an approximate factor. Any attempt to give pine cord wood a value must mean very little, it varies so widely in different situations; so the price ($3 per cord) is merely nominal.

Yield from Thinnings.

Trees under 5 inches, from report of the New Hampshire Forestry Commission, 1906.

Age (Years).	Trees over 5 Inches in Diameter.				Trees under 5 Inches in Diameter.		
	Board Feet.	Value at $16 per M.	Stumpage at $6.	Cubic Feet.	Cords.	Value at $3 per Cord.	Cubic Feet.
25, . .	1,400	$22 40	$8 40	280	7½	$22 50	750
30, . .	3,700	59 20	22 20	720	6	18 00	600
35, . .	4,950	79 20	29 70	850	4½	13 50	450
40, . .	6,000	96 00	36 00	1,030	3	9 00	300
45, . .	6,800	108 80	40 80	1,140	1½	4 50	150
50, . .	7,400	118 40	44 40	1,240	-	-	-
55, . .	7,900	126 40	49 40	1,310	-	-	-

GROWTH TABLES.

Growth in Volume.

Growth tables of pine show the increase in the bole of the individual tree in volume expressed in cubic feet of solid wood. They are to be distinguished from the yield tables, which show the growth of pine by the acre. Although tables expressed in board feet might be better understood, it is necessary to use the cubic foot as a unit, because the stump and top must be included, and also because the cubic foot

unit is much more accurate for purposes of scientific measurement.

The material for tables of growth is obtained from a series of measurements called a "stem analysis." The trees as they are felled and sawed into logs are subject to the following measurements: the diameter at the top of the stump and its height are taken, also the diameters at the bottom and top of each log and its length, the diameter at the base of the top and its length. All of these diameters are measured inside of the bark. The stump is cubed as a cylinder, each log as the frustrum of a parabaloid and the top as a [redacted] cone. This gives us, as accurately as need be, the cubical contents of the trunk of the tree, inside the bark, at the present time. By counting back on the annual rings at each cut and taking the diameter at those points, we can obtain the cubical contents of the tree as it was ten years ago, twenty years ago, and so on back until it was in the neighborhood of ten years old.

Two hundred and forty-five analyses were made at twelve mills, the location of each tree described, and all the analyses gathered into four recognized types, viz., "rich lowland," "upland pasture," "sandy soil" and "wet swamp."

The trees in the rich lowland type grew near the banks of a stream or on the border of a swamp, where the soil was deep, rich and moist, but withal well drained. This type shows the most rapid growth of the four.

Upland pasture is the type that contains the largest part of our woodland growth, situated back from the brook and river bottoms on the hillsides and upland plateaus. The soil is a loose loam of moderate depth, stony, and in general unfit for agriculture. That the rate of growth here is not far below that of the previous type indicates what is found

to be generally true with trees, especially pines, — that they make few demands on the fertility of the soil, and require only a moderate amount of moisture.

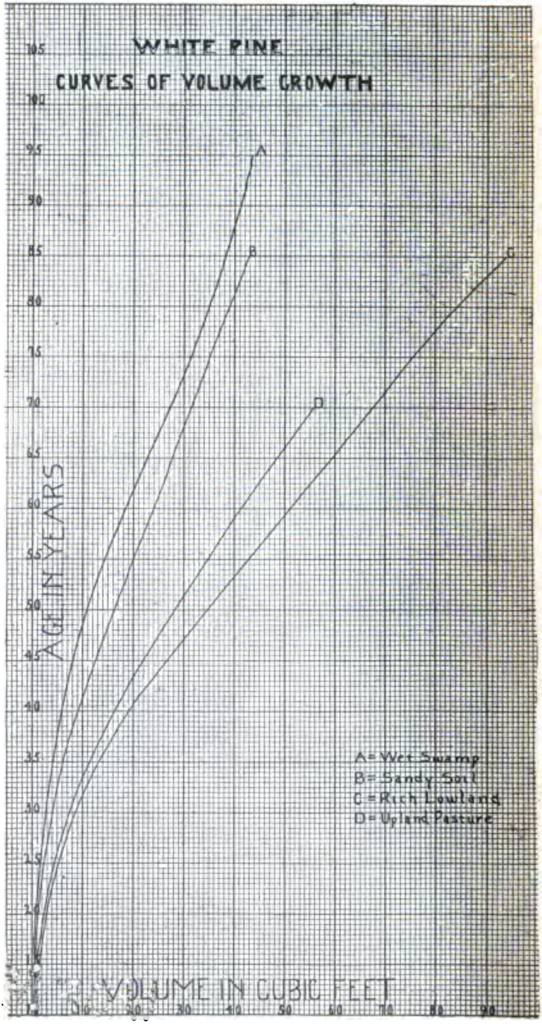
The stem analyses for the sandy soil type were made at Kingston, Plymouth County, on an upland plateau; and, although the number of trees measured is too small to be conclusive, the results seem to indicate that the dry, sandy soil of southeastern Massachusetts does not allow of such rapid growth as the more favored soil in other parts of the State. Down to a certain point, decrease in moisture does not have much effect on the rate of growth; but below that point the tendency to retard the development of the tree becomes rapid.

The slowest growth is found with trees growing in wet, mucky swamps, where the drainage is poor and the roots of the trees are under water at least part of the year. Too much water is as fatal to the tree as too little. It is of interest to note, in this connection, that many of the trees measured for this type were only a few yards away from trees included in the rich lowland type of most rapid growth.

We append the curves drawn on cross-section paper, where one inch (before being reduced in printing) on the abscissæ represents ten cubic feet of volume, and one inch on the ordinates five years in age. The purpose of the curves is to visualize the tables, making the variations between the types evident to the eye in a way that columns of figures fail to do even to the extra-studious.

Growth Tables.—Growth in Volume.

AGE (YEARS).	Rich Lowland. 109 Trees.	Upland Pasture. 73 Trees.	Sandy Soil. 16 Trees.	Wet Swamp. 47 Trees.
	Cu. Ft.	Cu. Ft.	Cu. Ft.	Cu. Ft.
10, ...	.8	.6	.4	.3
15, ...	1.8	1.2	.5	.4
20, ...	3.0	2.0	1.4	1.0
25, ...	5.5	4.5	2.5	1.6
30, ...	9.0	7.5	4.0	2.7
35, ...	13.5	11.5	6.3	4.0
40, ...	19.5	16.6	9.3	6.0
45, ...	26.5	22.0	12.5	8.3
50, ...	35.0	27.7	16.0	10.7
55, ...	43.5	34.5	19.8	14.5
60, ...	51.5	41.7	23.6	18.6
65, ...	60.0	49.0	27.5	23.0
70, ...	68.0	56.0	31.2	27.2
75, ...	75.5	–	35.3	31.2
80, ...	84.0	–	39.0	34.8
85, ...	93.5	–	42.8	38.0
90, ...	–	–	–	41.0
95, ...	–	–	–	43.5


WHITE PINE
CURVES OF VOLUME GROWTH
AGE IN YEARS
VOLUME IN CUBIC FEET
A
B
C
D
A = Wet Swamp
B = Sandy Soil
C = Rich Lowland
D = Upland Pasture

Growth in Height.

From the stem analyses it is possible also to obtain the rate of growth in height.

The most noticeable point about the table in height growth is the early culmination of its most rapid period, which varies from twenty-five years of age in the "sandy soil" type to fifty years in the "upland pasture." The volume growth, on the other hand, does not culminate within the limits of age expressed in these tables except in the case of the "swamp" type, where there is a slight reversal of the curve about the seventy-fifth year. This difference is due to the fact that increase in volume is due more to growth in diameter than to growth in height, and that the diameter growth does not begin to slacken until the tree becomes quite old. When a tree becomes old and large, a comparatively narrow annual ring added to it each year means a much larger accession in volume than the same ring of growth added to a smaller tree.

In the rate of height growth, "upland pasture" exceeds slightly the "rich lowland" type, although in volume growth it is somewhat less. This is because the trees of the "upland" type grew in dense stands, which have a tendency to produce tall, spindling trees, known to lumbermen as "sapling pine;" while the "lowland" type tree grew in a more open stand, scattered among hard woods or other conifers, where there is not so much forcing of growth upward, but plenty of opportunity given for increase in diameter.

In the table the height at which the growth figures at approximately the rate of one foot a year is expressed in bold-faced type. This age decreases from ninety years in the "upland pasture" to only thirty-five years in the "swamp" type, showing that under favorable conditions a good rate of

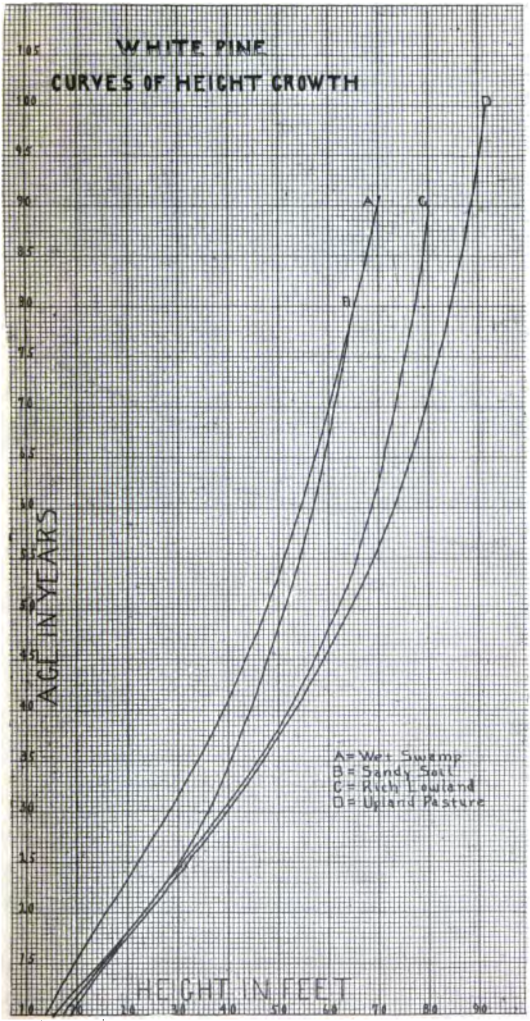
growth can be sustained for a much longer time than under poorer conditions.

To summarize, the pine tree may be said to grow at the rate of about one foot a year for the first fifteen years, after which to the forty-fifth year this growth in height is accelerated, oftentimes to an average of two feet a year. The growth then gradually slackens until after the eightieth year, when it becomes only a few inches annually.

Figures of other species are not before us, but the white pine is undoubtedly one of the most rapid-growing trees native to this State, as well as the most useful and the one in greatest demand. Its moderate demands as to fertility and moisture and its adaptability to all sorts of conditions of climate and exposure, are further arguments that lead to the conclusion that it is the tree best suited for planting purposes in Massachusetts.

Growth Tables. — Growth in Height.

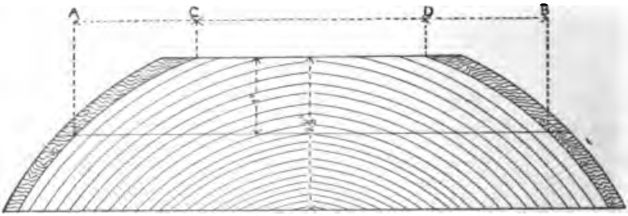
Age (Years).	Upland Pasture. 73 Trees.	Rich Lowland. 109 Trees.	Sandy Soil. 16 Trees.	Wet Swamp. 47 Trees.
	Feet.	Feet.	Feet.	Feet.
10,	9	8	5	4
15,	16	15	14	10
20,	24	23	23	16
25,	32	31	30	22
30,	40	39	36	28
35,	47	46	40	34
40,	53	52	44	39
45,	59	57	48	43
50,	64	62	51	48
55,	69	66	54	51
60,	73	69	57	54
65,	76	71	59	57
70,	80	73	61	60
75,	82	75	63	62
80,	84	77	65	65
85,	87	79	-	68
90,	89	80	-	70
95,	90	-	-	-
100,	91	-	-	-


WHITE PINE
CURVES OF HEIGHT GROWTH
AGE IN YEARS
HEIGHT IN FEET
A
B
C
D
A = Wet Swamp
B = Sandy Soil
C = Rich Lowland
D = Upland Pasture
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
10
20
30
40
50
60
70
80
90

MISCELLANEOUS NOTES.

Under this heading has been grouped several facts of interest chiefly to lumbermen and mill owners, which have come under our notice in the investigations of the previous subjects. They are not backed by enough data to make them conclusive, but they are offered for what they are worth.

We have placed in parallel columns the general log rule, called here the Massachusetts scale, together with special



Comparison of Scale in Sawing 2⅛ inch Plank and 1 inch Boards

log scales made at Mashpaug and Greenfield, for the purpose of comparing the different methods of sawing. These log scales represent nothing more than the average number of board feet obtained from logs of the designated size at those mills.

At the Greenfield mill a large proportion of 2⅛-inch plank was sawed; while the Massachusetts scale is made from logs cut chiefly into 1-inch boards. It will be noticed that in the case of the 12 and 14-foot logs the inch board rule runs a little higher than the 2⅛ rule. This may seem strange at first sight, because the natural inference is that, owing to the saw kerf saved in sawing thick plank, there should be an increase in the yield of the log. Prof. Austin

Cary offers this solution, namely, that something is lost in scaling. The surveyor scales on the narrow face of the plank, C–D in the diagram, and multiplies the scale by two; whereas, if the plank were made into two 1-inch boards he would scale the distances C–D and A–B, so that in the present instance he loses the scale of A–C and B–D. There is a greater percentage of difference between the two rules in the case of logs of small than those of large diameter, because the amount of wane in plank taken from the smaller

Comparison of Log Scales.

Diameter at Small End (Inches).	8-Foot Logs.		10-Foot Logs.			12-Foot Logs.			14-Foot Logs.		
	Mashpaug.	Greenfield.	Mashpaug.	Massachusetts.	Greenfield.	Mashpaug.	Massachusetts.	Greenfield.	Mashpaug.	Massachusetts.	Greenfield.
	B. M.	B. M.	B. M.	B. M.	B.M.	B. M.	B. M.	B.M.	B. M.	B. M.	B.M.
4, . .	10	6	12	9	8	15	13	11	20	17	13
5, . .	14	10	17	13	12	21	17	15	26	21	18
6, . .	19	15	23	17	17	27	22	20	34	27	24
7, . .	25	20	30	23	23	35	29	26	43	35	32
8, . .	33	27	38	30	30	45	37	34	54	44	40
9, . .	42	35	49	39	39	57	47	44	67	55	49
10, . .	53	45	61	48	49	71	58	54	81	68	60
11, . .	65	56	75	58	60	86	70	66	98	82	74
12, . .	77	68	90	69	73	102	83	80	116	97	91
13, . .	90	-	107	80	-	121	96	97	136	113	110
14, . .	-	-	124	104	-	142	111	116	158	131	131
15, . .	-	-	-	117	-	166	129	-	180	150	153
16, . .	-	-	-	131	-	-	146	-	204	170	-

logs is much greater. The reason that the 10-foot logs do not indicate the differences in the methods of sawing, is that they were sawed chiefly into 1-inch boards at Greenfield as well as elsewhere.

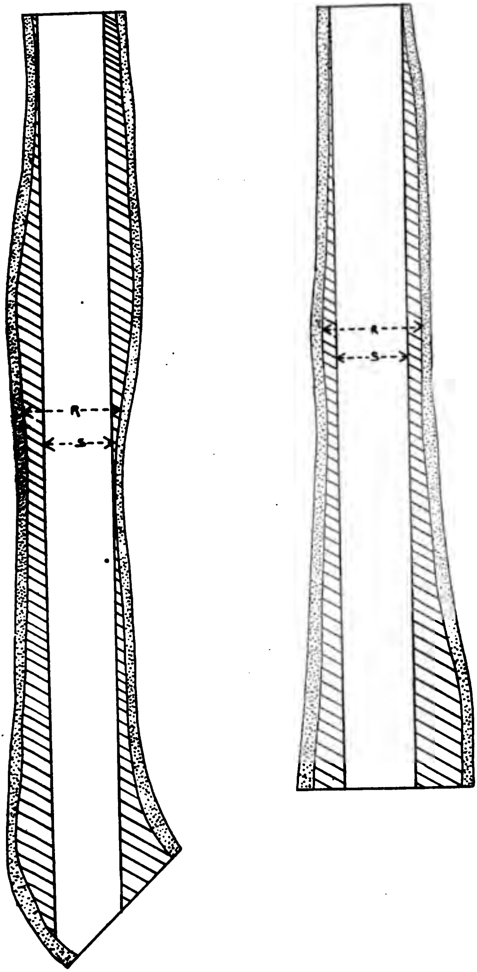
The Mashpaug scale was made at a portable mill equipped with a band saw, which cut a ⅛-inch kerf. The saving in

A PORTABLE SAW-MILL.

lumber caused by a kerf which is one-half the width of that made by an ordinary circular saw is evident on comparison of the scales. It averages more than 20 per cent.

This mill needs to be set on a firmer foundation than one of the circular type; it requires a well-trained sawyer to care for it, special machinery for filing the saw, and cannot be rushed to the same degree that a circular saw can; yet it seems that the saving in lumber would more than compensate for these inconveniences.

Professor Cary constructed a log scale from mill tallies at a portable mill in Maine which was sawing pine into



Loss of Scale in Squaring Round-Edged Boards

square-edge boards exclusively. His rule and the Massachusetts scale are here compared, to show the difference in the two methods of sawing. The logs which made up the data for Mr. Cary's rule came from extra large, tall, straight trees, so that the difference between the scales is not as striking as it would otherwise have been were they an average lot, such as is represented by the Massachusetts scale. The difference in favor of the round-edge scaling is greatest in the case of the small logs, and decreases inversely with the size of the logs. Theoretically, the difference should have zero as a limit; but, on account of the extra fine quality of the Maine logs in the largest diameter classes, the round-edge figures give smaller results than the square-edge.

Round-edge boards are scaled on the narrow face, inside the bark at the place of average width. The determination of the average width is left entirely with the scaler. On the other hand, if the same board were squared, its width would be limited by that dimension at the small end, or some other narrow point. The two diagrams show the effect of squaring two boards, one with an excessive amount of taper and one with a bad crook. The dotted line R represents the scale of the round-edge board, and the line S the scale of the square-edge board. Although there is considerable loss in scale, there is even a greater loss in lumber.

There are three probable reasons why the difference between the two methods of sawing is greater in the case of small logs than of large ones: first, the small logs come from the top cuts, and have more taper and crooks than those lower down on the tree; second, there is a large percentage of square-edge stuff manufactured from the large logs in the Massachusetts mills; third, it has been stated before that the figures of the Massachusetts log scale are inclined to underrun in the case of the largest logs.

Diameter at Small End (Inches).	12 Feet.			14 Feet.		
	Cary.	Massachusetts.	Per Cent. Difference.	Cary.	Massachusetts.	Per Cent. Difference.
	Bd. Ft.	Bd. Ft.	Bd. Ft.	Bd. Ft.	Bd. Ft.	Bd. Ft.
6, ...	20	22	10.00	23	27	17.39
7, ...	26	29	11.53	30	35	16.66
8, ...	33	37	12.12	39	44	12.82
9, ...	43	47	9.34	50	55	10.00
10, ...	54	58	9.25	61	68	11.47
11, ...	67	70	4.46	75	82	9.33
12, ...	81	83	2.46	90	97	7.77
13, ...	95	96	1.05	105	113	7.61
14, ...	110	111	.90	124	131	5.64
15, ...	128	129	.78	135	150	1.11
16, ...	147	146	—.79	160	170	.62
17, ...	172	165	—4.07	-	-	-
18, ...	202	184	—8.91	-	-	-

EQUIVALENT FACTORS.

The volumes of 12-foot logs of nineteen diameters (diameters outside bark at middle of the log) were used to make this table. The cubic-foot volume was obtained by cubing the log as a cylinder; the board-foot volume was taken from the Massachusetts log rule; and the cord-foot volume obtained from the caliper rule. From this data we have been enabled to get the number of board feet which can be sawed from a log of designated size per cubic foot of its solid contents, and also the number of board feet contained in a caliper cord made up of logs of the indicated dimensions. The figures as they stand are not important, but are offered

to show the tendency of the factors to increase along with the increase in the size of the log; that is, the larger the log the greater number of board feet which can be obtained from it per unit of solid wood, and that a cord of wood made up of large logs will yield more boards than are made up of small logs.

The same general rule applies to the standing trees, but not in the same ratio; for, using a 12-inch log as an average,

A TYPICAL BOX FACTORY, CHAFFEE BROS., OXFORD, MASS.

we see from the table that the factor in the fifth column is 6.8 and in the sixth column 654; while for a 12-inch tree, 60 feet in height, the factors are respectively 6.5 and 610.

The measurement of a carload of short box-board logs, containing 11 cords, resulted in showing that there are from 97.3 to 102.4 cubic feet of solid wood in a cord of pine as piled, not caliper rule cords. These figures are not, however, satisfactory, as the carload was made up of logs 48 and 50 inches in length, which were so intermingled that

they could not be separated. This would tend to make the above figures a little large; but, on the other hand, they were very poor logs, many of them hard pine, which fact might compensate for the advantage given by the logs of extra length. It is of interest to compare these figures with 96 cubic feet, which is the solid contents of a cord of spruce pulpwood in Maine, and 70 cubic feet, the solid contents of an ordinary cord of hard wood firewood.

Table to show Equivalent Factors for changing Cubic Feet to Board Feet and Cords to Board Feet.

Diameter at Middle of Log (Inches).	12-Foot Log (Cubic Feet).	12-Foot Log (Board Feet).	12-Foot Log (Cord Feet).	Number of Board Feet per Cubic Foot of Solid Wood.	Number of Board Feet per Cord.
5,	1.6	12	2.1	5.0	488
6,	2.3	16	3.0	5.6	560
7,	3.2	20	4.1	6.0	590
8,	4.2	26	5.3	6.4	636
9,	5.3	33	6.8	6.5	645
10,	6.5	41	8.3	6.6	646
11,	7.9	51	10.1	6.7	648
12,	9.4	62	12.0	6.8	654
13,	11.1	73	14.1	6.8	684
14,	12.8	85	16.3	6.9	707
15,	14.7	99	18.8	7.0	714
16,	16.7	116	21.3	7.1	714
17,	18.9	132	24.1	7.2	721
18,	21.2	148	27.0	7.3	726
19,	23.6	166	30.0	7.4	733
20,	26.2	185	33.3	7.4	738
21,	28.9	204	36.8	7.4	744
22,	31.7	226	40.3	7.5	752
23,	34.6	250	44.1	7.5	742
24,	37.7	275	48.8	7.5	730

FROM "WOODSMAN'S HANDBOOK," PART I.[1]

BULLETIN 36.—H. S. GRAVES.

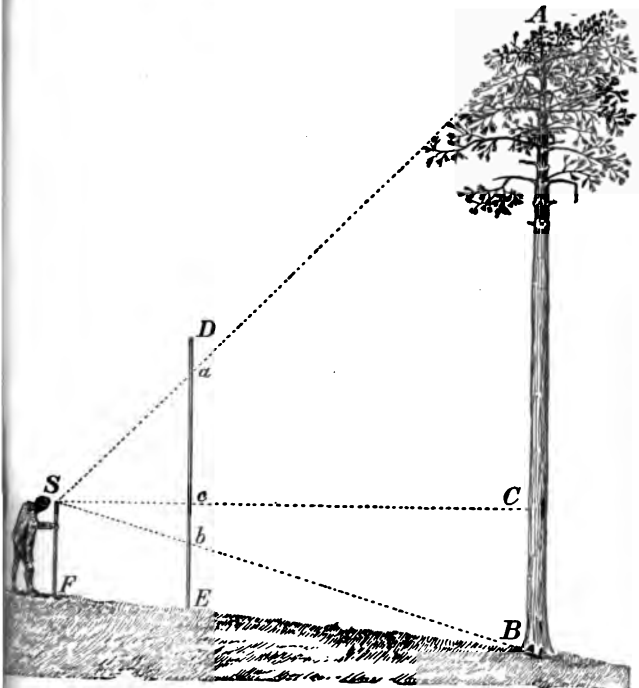
INSTRUMENTS FOR MEASURING HEIGHTS.

There are several methods of determining the height of a standing tree. One of the simplest is to measure the shadow of the tree and the shadow of a straight pole of known length set perpendicular to the earth. Multiply the length of the shadow of the tree by the length of the pole and divide the product by the length of the shadow of the pole. The result will be the height of the tree.

A method used when the sun is not shining is to set two poles in a line with the tree. (See Fig. 1.) From a point on one pole sight across the second pole to the base and to the top of the tree. Let an assistant note the points where the lines of vision cross the second pole and measure the distance between these points. Also measure the distances from the sighting point on the first pole to the base of the tree and to the lowest vision point on the second pole. Multiply the distance between the upper and lower vision points on the second pole by the longer of the other two measurements and divide by the shorter; the result will be the height of the tree.

Example: Let $ab=6$; $Sb=4$; and $SB=30$; then $\frac{6 \times 30}{4}=45$, height of tree.

[1] By permission of United States Department of Agriculture, Forest Service.



ᴵᴳ. 1. — Measuring the height of a tree by means of two poles. (Graves, Bulletin 36, Forest Service, United States Department of Agriculture.)

FAUSTMANN'S HEIGHT MEASURE.

This instrument, shown in Fig. 2, consists of a skeleton ctangular metal frame having two crossbars at one side f its longitudinal center, the frame and bars being in one ece. A slide, reversible end for end and having beveled ges, works in under-cut grooves formed in the inner edges

of the crossbars. This slide is provided at its ends with thumb notches, and with transversely arranged index marks, designated I and II. A plumb line carrying a plummet is attached to the slide in the center of the index mark II. A retaining spring secured to the back of the

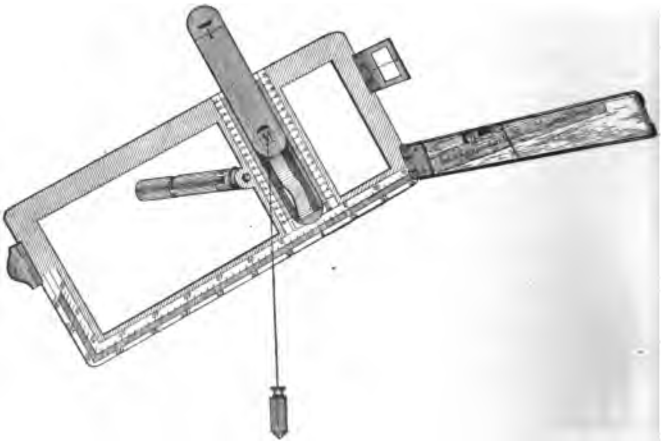


FIG. 2.—Faustmann's height measure. (Graves, Bulletin 36, Forest Service, United States Department of Agriculture.)

frame and bearing against the inner face of the slide holds it in any position in which it may be set. The left-hand end bar of the frame is furnished with an eyepiece, and the right-hand end bar with an objective, these being made of metal and hinged so as to be folded down out of the way when the device is not in use. A long, narrow mirror, hinged to the frame at a point below the objective, is furnished to reflect a right-hand horizontal scale and a left-hand horizontal scale engraved upon the lower bar of the

frame, and meeting at
a line passing through
The right-hand scale r
225, the latter scale ex
bar of the frame. The
a vertical scale runni
continued on the left-
upward to 175. These
bered. The lines form
from each other and r
system of measuremen
of the device is attach

FIG. 3. — Manner of using F
tin 36, Forest Service, U

To use the instrume
ontal distance in feet,
rom where he is to st